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AEC-NASA TECH BRIEF

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Mathematical Relation Predicts Achievable Densities of Compacted Particles

The problem:

To develop a method of predicting achievable densities of compacted particles in a cylindrical container. Until the present time, no simple method has been suggested for predicting the uniform densities of compacted particles.

The solution:

A series of mathematical relationships for predicting (1) compact densities of spherical shapes in a cylinder as a function of particle dimension, and (2) compact density of angular shapes as a function of particle shape and absolute size.

How it's done:

An investigation was carried out to determine the mathematical relation of the diameter of spherical particles and their density when compacted. A second study was carried out to relate the packing characteristics of angular particles to the model case of spheres.

The relation for the packing efficiency of spherical particles in a cylinder was developed as:

$$P_e = 0.635 - 0.219_e^{-0.313\ D/d_1}$$

Further, the relation for the packing efficiency of spherical particles within a matrix of spherical particles is:

$$P_e = 0.635 - 0.737_e^{-0.201\ d/d}$$

where P_e is the packing efficiency

D is the diameter of the cylinder

d_1 is the diameter of the spherical particles

d/d is the ratio of diameters of larger to smaller spherical particles

The predicted densities show agreement within ±0.015 with densities achieved in practice. Prediction of achievable densities of spherical particles or aggregates of angular particles by these methods reduces the time and inaccuracies involved in graphical solutions or extrapolations from similar systems.

Notes:

1. The compaction of spherical shapes was done using a vibrator, an oscillator, a bank of amplifiers, and an accelerometer. Various sizes of steel shot and bearings were compacted together in a cylinder; first compacting the largest size, then the next largest, and then the smallest size. The results were interpreted from graphs plotting void packing efficiency versus sphere-to-sphere and container-to-sphere diameter ratios.
2. The compaction of angular shapes was done similarly, but using various sizes of malleable grit as the particles. Two types, ball-milled (tetragonal) and angular grit, were used in this study. The results were interpreted from graphs plotting void packing efficiency of angular grit versus ratio of diameter of container to particle dimension, and plotting void packing efficiency of ball-milled grit versus ratio of diameter of container to particle dimension.
3. Additional details may be found in the following issues of the *Journal of the American Ceramic Society*, (a) Vol. 49, No. 4, April 1966, pp. 207–210; (b) Vol. 48, No. 4, April 1965, pp. 180–183. Information is also contained in Patent No. 3,261,378, which is available from the U.S. Patent Office $0.50 each.
4. Inquiries concerning this innovation may be directed to:

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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